49h 24 N 2 m 3

PATENT SPECIFICATION

DRAWINGS ATTACHED

Inventors: LESLIE ALBERT FORD, ALAN SYDNEY DARLING

1,154,323

1,154,323

Date of filing Complete Specification (under Section 3 (3) of the Patents Act 1949): 22 Aug., 1966.

Application Date: 24 Aug., 1965. *No. 36291/65.*

Application Date: 18 Jan., 1966. *No. 2261/66.*

Complete Specification Published: 4 June, 1969.

Index at acceptance:—**B3** R(2G, 60); **B3** A98; **B3** P(3, 10B1, 16D)

Int. Cl:—**B 23 k 35/04**

COMPLETE SPECIFICATION

Improvements in and relating to Spot-Welding Electrodes

We, JOHNSON MATTHEY & CO. LIMITED, a British Company of 78, Hatton Garden, London, E.C.1., do hereby declare the invention, for which we pray that a Patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to spot-welding electrodes.

Among the properties required of a spot-welding electrode are that it should have good thermal and electrical conductances and that, in use, it should be resistant to deformation, at least at its working end or tip, when subjected to mechanical stress at temperatures equal to or closely approaching the welding temperature at the workpiece. The reasons for this are as follows:—

The process of spot-welding is commonly used to produce small-area welds between two relatively thin sheets of metal and is generally carried out by clamping the sheets firmly between two axially-aligned water cooled electrodes and then passing a heavy current from one electrode to the other through the sheets. Under these circumstances, resistance heating of the sheets occurs particularly at the interface between them where they are held in contact. This is due to the relatively high electrical resistance between the sheets in the region of contact and in practice the rate of heat generation is such that at least the contiguous surface layers of the sheets in this region are fused, so that on cooling the sheets are welded together. When a pair of sheets is welded together in this way, it is necessary to prevent a similar process occurring at the regions or contact between the electrodes and the sheets.

This is done by circulating cooling water through the body of each electrode so as to prevent the temperature of its tip from reaching a value at which it will itself weld to the sheet. Despite this precaution, the temperature of each electrode tip does rise to a value approaching the welding temperature of the sheets during each welding operation.

Further, in order to achieve the necessary contact between the sheets, it is necessary to clamp them together with considerable force by means of the electrodes. It follows that during each welding operation the tip of each electrode is subjected to considerable mechanical stress at temperatures approaching the welding temperature of the workpiece.

For these reasons, at least the tip of a spot-welding electrode must i) be resistant to deformation at temperatures approaching the welding temperature. Further, such an electrode must ii) have a high electrical conductance so that it may carry the necessary heavy current without being unduly heated by the passage of the current. Also, the electrode must iii) have a high thermal conductance so that water-cooling the body of the electrode will effectively cool its working tip.

Unfortunately, these requirements for a spot-welding electrode of high thermal and electrical conductances and good hot strength are to an extent incompatible, since materials such as copper which well satisfy the first two requirements do not satisfy the third whilst materials having particularly good hot strength generally have relatively poor thermal and electrical conductivities.

If a spot-welding electrode is made from a relatively soft (but highly conductive) material, such as copper, the high temperatures and pressures to which the electrode tip is subjected in use cause it to spread out or "mushroom" fairly rapidly. When this occurs it becomes necessary to interrupt the sequence

OCTR. FAM.

of welding operations and to remove the electrode so that its tip may be restored to its original shape. This is generally done by remachining the tip or by "dressing" it with a hand file.

On the other hand, if an electrode is made of a hard, highly deformation-resistant material which has low electrical and low thermal conductivity the current required for welding would, during operation, cause overheating and consequent softening of the electrode material leading to "mushrooming" of the electrode. In extreme cases, the electrode may tend to melt and fuse to the workpiece.

It has accordingly become the practice to use electrodes made of materials whose properties lie intermediate the extremes mentioned above and which have electrical and thermal conductivities comparable with those of copper and strengths at elevated temperatures which are significantly higher. Typical of these materials is a range of chromium-copper alloys, with or without the addition of small quantities of one or more of the metals beryllium, cobalt and zirconium, which have been developed for the manufacture of spot-welding electrodes. Electrodes made from these alloys are, nevertheless, still prone to "mushrooming", although less than with copper electrodes.

According to this invention a spot welding electrode having a tip with an operative contact face includes a reinforcing member or members extending as an insert of general continuous annular shape into the electrode at least from the peripheral zone of contact as herein defined, said member or members being formed of a conductive material having greater strength and resistance to deformation under welding conditions than the material forming the electrode.

We have found that such a reinforcing member or members considerably reduces "mushrooming".

In one form of spot welding electrode, the reinforcing member is a tubular tightly fitting insert located in the electrode tip so that one end face of the insert coincides with and forms the peripheral zone of contact of the electrode tip.

By "peripheral zone of contact" is meant an annular zone, the outer perimeter of which either coincides with or lies adjacent and conforms closely to the periphery of the contact face.

The resistance to deformation of the insert at elevated temperature and the electrical and thermal conductivity of the electrode material are as high as possible.

Preferably, the insert is cylindrical and the outer periphery of the said one end face is chamfered, tapered, or otherwise shaped to produce a welding tip of the desired profile. It will therefore be appreciated that the insert end face not only constitutes the peripheral zone of contact but also presents the relatively harder material of the insert in that region of the contact face of the tip where "mushrooming" usually occurs.

It is desirable for the conductivity of the insert material to be as high as possible consistent with the need to avoid softening of the insert during operation. For example, in an electrode made from a copper chromium alloy having a conductivity of 80% International annealed copper Standard, we have found that satisfactory operation is obtained using an insert made from a material having an electrical conductivity of greater than say, 30% International annealed copper Standard, (I.A.C.S).

Where a number of reinforcing members of rod or strip form are used, adjacent members are located to touch each other. In effect, therefore, the members define a tube extending into the electrode from the "peripheral zone of contact" and having a continuous surface. If desired, the longitudinal section of tube may taper.

The rod or strip reinforcing members may be of circular, rectangular or arcuate cross-section. Where the members are of arcuate cross-section, these may constitute segments of a cylindrical tube.

It is usual for the tip of a spot welding electrode to be tapered or chamfered and, if desired, the reinforcing member or members may be located slightly inside the inclined surface so formed, or may constitute a part of parts of the inclined surface.

The invention also includes a method of making a spot welding electrode which consists in forming in that end of a billet of electrode material intended to form the electrode contact face, an annular recess at the peripheral zone of contact as herein defined and fitting a tubular reinforcing member as an insert into said recess so that the outer end face of said member lies flush with or slightly proud of said contact face, said member being formed of a conductive material having a relatively greater strength and resistance to deformation under welding conditions than the electrode material.

By the term "insert" used throughout this specification and claims is to be understood a body adapted to be inserted as a unit into a recess formed on the operative face of an electrode or to be built up in such a recess by the insertion of component parts of the body into the recess, each component part making contact with adjacent parts when the body is built up.

Electrodes in accordance with the invention will now be described by way of example, with reference to the accompanying drawings, in which:—

Figure 1 is a sectional elevation of part of an electrode according to the invention, including the working end;

Figures 2 and 3 illustrate stages in the manufacture of the electrodes;

Figure 4 shows graphically curves of Cm (as herein defined) against number of welds for electrodes with and without reinforcing inserts;

Figures 5, 6 and 7 show additional details of electrodes with and without inserts; and

Figure 8 shows a composite insert.

Figure 9 shows a billet intended to form an electrode and shaped to receive a cylindrical insert.

Figures 10A and 10E show various forms of cylindrical inserts.

The body 1 of the electrode, see Figure 1, is formed of a copper-chromium alloy known as "Mallory 3" ("Mallory" is a Registered Trade Mark) and the working tip of the electrode has a force fitted hollow cylindrical reinforcing insert 2, the end face 3 of which constitutes an annular, peripheral zone of the contact face 4 of the electrode tip. The insert 2 is formed of a material known as "Elkonite 30W3" ("Elkonite" is a Registered Trade Mark), and comprises a sintered mass of tungsten particles with the interstices between them filled with copper and has an electrical conductivity of not less than 27% IACS. The electrode includes a cooling cavity 1A.

Electrodes of the above type exhibit markedly increased resistance to "mushrooming" in service as compared, for example, with electrodes of the same size and shape made entirely from "Mallory 3" alloy and without the "Elkonite 30W3" insert.

Referring to Figure 4, in tests made to determine the relative resistance to "mushrooming" of "Mallory 3" electrodes with and without "Elkonite 30W3" inserts, pairs of these electrodes were used in an automatic spot-welding machine to joint together two strips of EN2B mild steel (a low carbon steel). Care was taken to ensure that the same welding regime was used with each pair of electrodes. After each pair of electrodes had been used for 10,000 welds one electrode of each pair was removed and its percentage "mushrooming coefficient" (Cm) determined.

By "percentage mushrooming coefficient" is meant

$$Cm = \frac{M-T}{M} \times 100\%$$

where M is the projected area of the "mushroomed" tip of the electrode on to a plane at right angles to the centre line of the electrode and T is the area, projected on to the same plane, which the tip would have had if its length has been reduced, without "mushrooming", by an amount equal to the loss of length occasioned by the "mushrooming" which actually occurred. "Mushrooming" of a tip is diagrammatically shown by the dotted lines in Figure 5. In Figure 4, curve A′ shows the results of the tests on the conventional electrodes and curve B′ those on the electrodes in accordance with the invention.

After 10,000 welds, the coefficient Cm for a "Mallory 3" electrode with an "Elkonite 30W3" insert was 1½%, whereas the coefficient Cm for an electrode made entirely from "Mallory 3" was 42%. Further, when the electrode according to the invention was used to make an additional 20,000 welds, the value of its Cm increased by a mere 1% to 2½%.

Experience with electrodes according to the invention has shown that the insert should be a tight mechanical fit within the working end of the electrode. The tighter the mechanical fit of the insert in the electrode, the lower the resistance to transverse flow of electricity and heat in the directions A and B (see Figure 1) and thus, in service the heat is more effectively conducted away from the electrode tip.

One way of making an electrode according to the invention is illustrated in Figures 2 and 3. In Figure 2, a cylindrical billet 5 of "Mallory 3" alloy is located within the cylindrical chamber 6 of a vertical "back-extrusion" press. The lower face of the billet 5 has a circular channel 7 formed therein into which there has been force fitted (as a preliminary operation) a hollow cylindrical insert 8 of "Elkonite 30WS". The height of the insert 8 is slightly larger than the depth of the channel 7 so that, after extrusion, the insert remains slightly proud of the lower end face of the billet 5, typically by about 0.005 inch. (This is not shown in the Figures 2 and 3).

When the billet 5 has been placed in the press as shown in Figure 2, a plunger 9 is driven into the upper face of the billet so as to deform it into the shape shown in Figure 3. As shown, the action of the plunger spreads the billet radially until it bears against the inner wall of the chamber 6 and "back extrudes" some of the material of the billet between the plunger and the chamber wall to form the longitudinal cavity 1A within the billet. This cavity, forms the cooling water cavity in the finished electrode. After removal of the deformed billet from the press, the lower end is machined to the shape shown in Figure 1, and the upper end is tapered to enable the finished electrode to be fitted into a standard electrode holder. Alternatively, instead of forming the cavity by back extrusion, it can be drilled out.

The major dimensions of an electrode in accordance with this invention are indicated in Figure 7 by letters and for purposes of comparison a conventional electrode, also dimensioned, is indicated similarly in Figure 6. In these Figures the dimension A=3/16 inch, B=1/4 inch, C=5/16 inch, D=3/4 inch, E=1/4 inch and F=0.62 inch.

Although the embodiment described above refers to the use of "Mallory 3" alloy with a hollow cylindrical insert of "Elkonite 30W3", the electrode may, for example, be made of any of the metals or alloys which are used for the manufacture of spot-welding electrodes and the insert may be of any metallic material which is stronger at elevated temperatures than the material of the electrode into which it is fitted. Of the materials which may be used for the insert, tungsten or molybdenum or alloys consisting principally of either or both of these metals, or materials, consisting principally of a sintered aggregate of tungsten or molybdenum particles or both, are particularly suitable.

Figure 8 shows an insert consisting of circular rods 11 arranged in circular tube formation. As shown, the rods touch each other. Alternatively the rods could be of square or rectangular cross-section.

Figure 9 shows a billet 20 from which an electrode body is formed. The billet 20 has a central projection 21 and an annular recess 22 for receiving a generally tubular reinforcing insert, previously designated 2. To assist insertion of a cylindrical reinforcing insert, (see Figure 10A), the outer periphery 23 of the annular recess 22 is cut back slightly to form a chamfered bevelled or curved edge. To secure the insert in position, the central projection is swaged or peened and, thereafter, the billet is machined to the required shape.

A number of differently shaped reinforcing inserts are shown in Figures 10A to 10E. Figure 10A shows, as mentioned above, a cylindrical insert, Figure 10B shows a cylindrical insert having the inner peripheral surface of what, when assembled, is the outermost end of the insert cut away at an angle of 30°, as shown at 24.

It will be appreciated that by swaging and peening, material from the central projection 21 is forced outwardly against not only the inner surface of the insert but also the triangular sectioned annulus between the insert and the projection by virtue of the bevel 24 of the inner surface, thereby securing the insert in the recess 22.

Another modification of the insert is shown in Figure 10C in which the outer peripheral surface of what, when assembled, is the innermost end of the insert, is bevelled.

The insert shown in Figure 10D is a combination of the inserts shown in Figures 10B and C.

Figure 10E shows an insert having a tapered bore. The taper of the bore is such that the largest diameter is located at what, when assembled, is the outer most end of the insert.

Although swaging and peening, back extruding of the billet around the material, and force fitting an insert within a recess formed in the billet result in satisfactory thermal and electrical contact between the insert and the billet, such contact may be improved by placing a layer of silver or silver based alloy between the insert and the recess.

The layer of silver or silver based alloy may be introduced in the form of an annular washer placed at the root of the recess. In this way, application of pressure to the insert during force fitting, back extrusion or swaging will not only cause deformation of the washer material to form good contact between the insert and root of the recess but also a certain amount of back extrusion of the washer material will take place between the inner and outer peripheries of the insert and the walls of the recess.

In an alternative method, the innermost end surface of the insert and/or the root of the recess may be coated with silver or silver based alloy.

WHAT WE CLAIM IS:—

1. A spot welding electrode having a tip with an operative contact face and including a reinforcing member or members extending as an insert of general continuous annular shape into the electrode at least from the peripheral zone of contact as herein defined, said member or members being formed of a conductive material having greater strength and resistance to deformation under welding conditions than the material forming the electrode.

2. An electrode according to claim 1 wherein the reinforcing member is tubular.

3. An electrode according to claim 1 or 2 wherein the insert consists of a metallic material having an electrical conductivity of not less than 27% I.A.C.S.

4. An electrode according to any preceding claim wherein the outer periphery of the outer end face of a reinforcing member is chamfered or tapered to conform with the shape of the electrode tip.

5. An electrode according to claim 1 wherein the reinforcing members are rods or strips.

6. An electrode according to claim 5 wherein the rods or strips are in circular tube formation with the rods or strips touching each other.

7. An electrode according to claim 5 or 6 wherein each rod or strip is of circular cross-section.

8. An electrode according to claim 5 or 6 wherein each rod or strip is of rectangular cross-section.

9. An electrode according to claim 5 or 6 wherein each rod or strip is of a cross-section which constitutes a segment of a cylindrical tube.

10. An electrode according to claim 1 wherein the or each reinforcing member is formed of sintered mass of tungsten particles with the interstices between them filled with copper.

11. An electrode according to claim 1 or

claim 10 wherein the body of the electrode is formed of a copper-chromium alloy.

12. A spot welding machine including an electrode according to any one of the preceding claims.

13. A method of making a spot welding electrode which consists in forming in that end of a billet of electrode material intended to form the electrode contact face, an annular recess at the peripheral zone of contact as herein defined and fitting a tubular reinforcing member as an insert into said recess so that the outer end face of said member lies flush with or slightly proud of said contact face, said member being formed of a conductive material having a relatively greater strength and resistance to deformation under welding conditions than the electrode material.

14. A method according to claim 13 which includes the step of subjecting the billet to compression in a back extrusion press to produce a cavity constituting a coolant chamber in the electrode.

15. A method according to claim 13 wherein at least the inner peripheral surface of the outermost end region of the tubular reinforcing member is bevelled and wherein billet material is deformed into contact with the tapered surface so as to secure the insert in the recess.

16. A method according to claim 13 wherein the inner surface of the reinforcing member is of tapered form having its maximum diameter at the outermost end of the insert.

17. A method according to claim 13 wherein the outer peripheral surface of the innermost end of the reinforcing member is bevelled.

18. A method according to claim 15 wherein the annular recess is formed so as to leave a central projection from which material for the said deformation of the billet material is obtained.

19. A method according to claim 13 including an annular washer of silver or a silver based alloy located at the root of the recess.

20. A method according to claim 13 including applying a coating of silver or silver based alloy to the root of the recess.

21. A method according to claim 13 including applying a coating of silver or silver based alloy to the innermost end of the insert.

22. A spot welding electrode made according to the method of any one of claims 13 to 21.

23. Spot welding electrodes substantially as herein described, with reference to the accompanying drawings.

WITHERS & SPOONER,
Chartered Patent Agents,
148—150, Holborn,
London, E.C.1.
Agents for the Applicants.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1969.
Published by the Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies may be obtained.

1154323 COMPLETE SPECIFICATION

5 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

Fig.1.

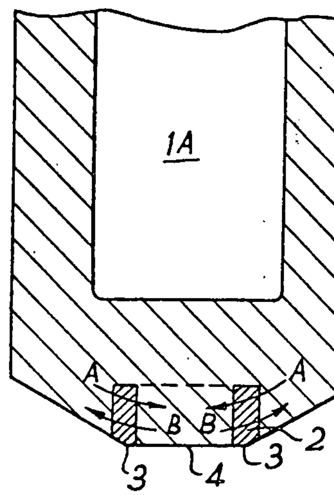


Fig.2.

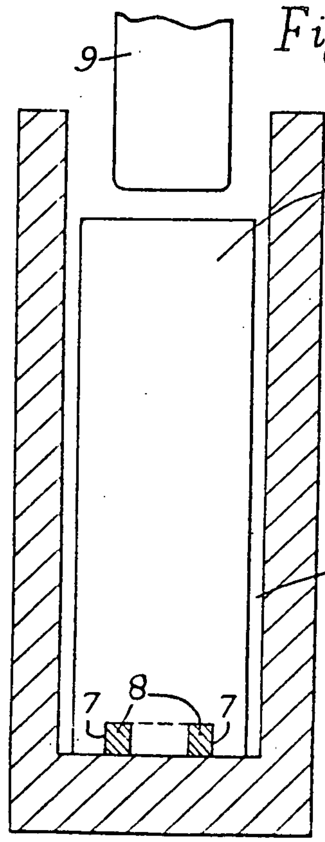


Fig.3.

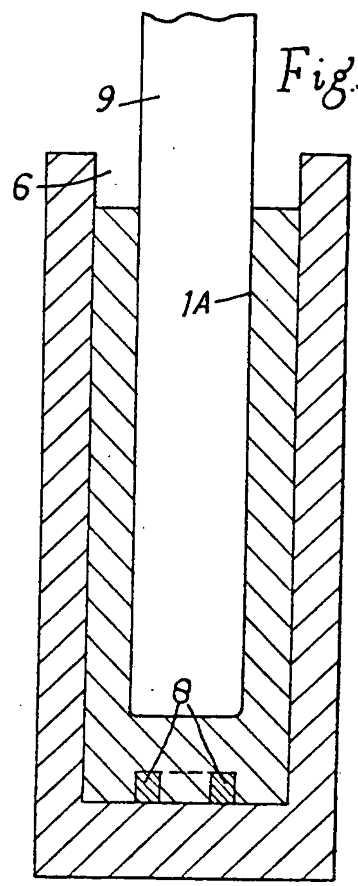


Fig. 4.

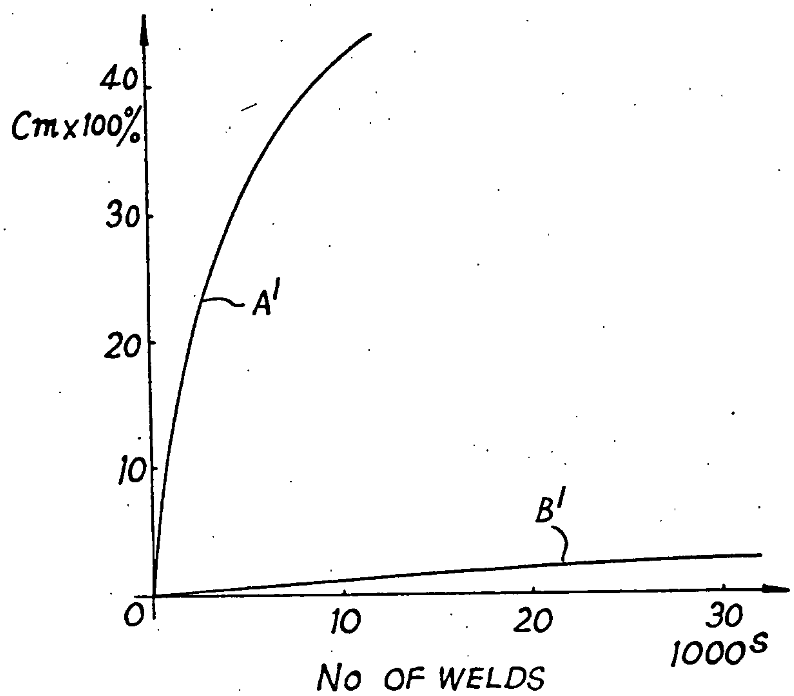


Fig. 5.

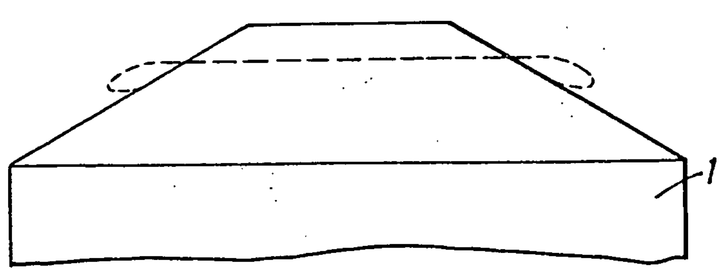
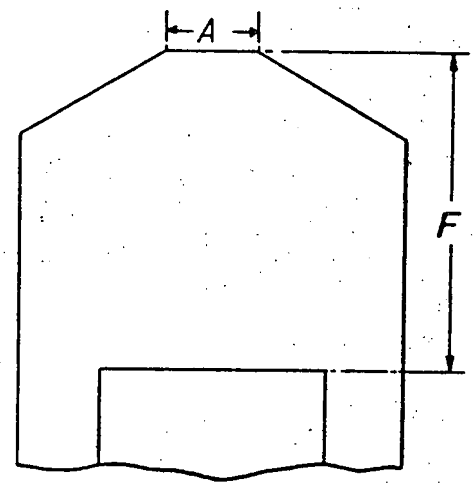


FIG.6.



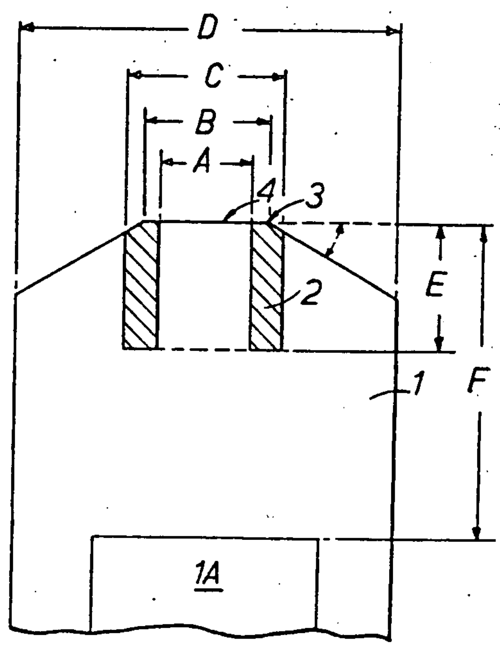
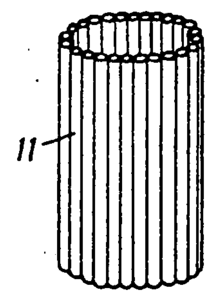


FIG.7.

Fig.8.



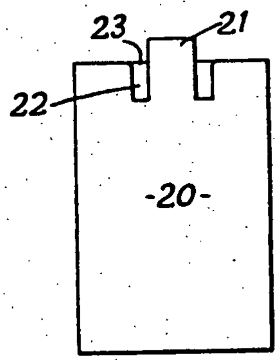


Fig. 9

Fig. 10A.

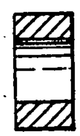


Fig. 10B.

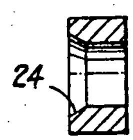


Fig. 10C.

Fig. 10D.

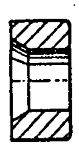


Fig. 10E.